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RESEARCH ANALYSIS CORPORATION

Concept Paper:

Computer-Assisted War Games

RAC

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Concept Paper:

Computer-Assisted War Games

by
Robert G. Hendrickson

RESEARCH ANALYSIS CORPORATION

McLEAN, VIRGINIA

FOREWORD

A great deal has been written on both computer technology and war-gaming techniques. The author calls on his wide range of experience as Manager of the Computer Science Center of the Research Analysis Corporation to combine both in an improved methodology of the computer-assisted war game. He shows how the visual-display concept outlined here, with its graphic data processing and other peripheral aids, can change a nominal capability to a sophisticated system permitting multiple war-game play.

C. R. Patterson
Vice President and Treasurer

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ABSTRACT

This paper explores in general terms the organization and characteristics of war games and develops the use of the application of display terminals and information processing equipment to war-game activities. The author identifies particular display requirements and analyzes the data flow between components of the game in order to establish at what nodal points display equipment can be of significant value in terms of increased response and report generation. A minimum equipment configuration is described that should provide war-gaming activities with a solid capability for increased and improved research output. The software requirements to support the computer-assisted war game, with particular emphasis upon the display aspect, is developed in general terms.

I—INTRODUCTION

A new era in computer technology is now providing exciting capabilities for graphic data processing. Many of the techniques are familiar and have been under development by the major computer manufacturers and also by noncomputer display-equipment vendors.

The general area of graphic data processing includes the display of data points or alphanumeric characters on cathode ray tubes (CRTs); plotting boards; production of 35-mm film chips for either input, output, or display purposes; and console or group display projection systems. Modern computer technology now has brought these once separate capabilities into an integrated system of peripheral gear synthesized into a total computing capability that treats display equipment as an inherent extension of the nominal computing power of the central computer. The user may now regard display equipment as additional utility functions directed by the central computer. For the first time the new generation of computers provides the necessary sophisticated data communications links on selector, multiplexor, or semiduplex channels with attendant software support to bring graphic data processing almost on a "real-time" basis to the user under the general control of the central processor.

This paper will show in general terms how such display equipment can provide developers of war games with capabilities for data manipulation that can shorten the length of time to play through a given scenario; increase the accuracy of computational procedures; improve report generation techniques; and provide immediate access to the detailed data on unit histories, materiel consumption, status-of-forces files, and sensitivity analysis.

The display equipment and its integration with a central computer in essense provides a service to the user. This service may be very sophisticated or may be only a basic minimal set providing elemental requirements. But the users of this service, whether engaged in war gaming or applied or basic research, can now pursue the analysis of data with intimacy heretofore not available; only the limitations of techniques appear to restrict the utilization of display equipment.

If any conclusion can be drawn, it is only that computing capabilities are on the threshold of new development. The future should witness an ever-increasing expansion of peripheral display applications bringing the user to his data on a real-time basis. Present computers, however advanced they may appear, are only precursors of future extensions of man-data automated complexes.

II—ORGANIZATION OF WAR GAMES

A war game may be considered to be a system of components interconnected by a communications network. The communications system may be diverse in character, ranging from an informal verbal message to a sophisticated electronic data link. Viewed as a system the war game has several basic components. Figure 1 shows a generalized characteristic network relating the RED and BLUE teams to the Control section and, in turn, the Control

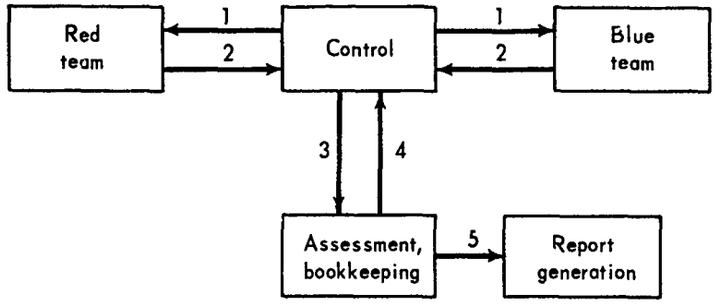


Fig. 1—Characteristic Communications Network for War Game
1, 2, 3, 4, 5—communication links.

section to the necessary assessment, bookkeeping, and report-generation functions. The communication links are shown in Fig. 1 as 1, 2, 3, 4, and 5. Without identification of the exact physical nature of the communication link, link 1 may be considered as the nexus for the passage and exchange of information regarding intelligence, rules, and game judgments; special instructions or decisions; the results of combat; the results of unit contact; and the status-of-forces reports. Link 2 serves as the exchange for information on team orders and activities, unit movements and activities, special reports, requests for information from Control, and requests for interpretation and clarification of rules. Link 3 provides for the flow of information dealing with the details regarding engaged forces; any special data that influence assessment of logistics, calculation of intelligence activities, special rulings, or model adjustments; and any special reports required by Control. Link 4 provides for the transference of information regarding unit movements, detailed calculations of ground and air combat, materiel consumption, and appropriate intelligence activities. Link 5 deals with all data pertinent to unit or force histories, the evaluation of activities in the context of game objectives, and data dealing with details of maps, overlays, etc.

The particular construction of the component parts of a war game and the communication links bringing them together into a detailed synthesis will depend on the function, scope, and objective of the war game and the resolution desired for the primary objectives and hypotheses to be tested. The extent to which the communication links serve a particular purpose and identify the utilization of the communication link in its role as a transference of information in and among components of the game structure is a natural consequence

of the game development. The more complicated and detailed the play of the game and resolution of the units the more complex will be the data flux being transferred. This paper will examine the nature of the data flow between game components and identify the communication needs that can best be served by remote-display equipments linked directly to a central computer to provide automation for those data-transfer functions best handled through computer technology.

III—IDENTIFICATION OF DISPLAY AND HARD-COPY REQUIREMENTS

The function of each of the data links described in Fig. 1 and discussed in some detail in section II can be categorized as to the type of information flowing through it and can in turn be associated as a proper computer function or not, as the case may be. The list of items for which communication links 1 are associated suggests that a communication link from a central computer under a lock-in/lock-out control feature under the auspices of Control would provide displays to the RED or BLUE teams as hard-copy printout or as visual display on the CRT in a format that best serves and informs the teams of the results of combat, contact, and status-of-forces reports.

The transferral of intelligence information from the Control section to the teams will depend on the nature of the intelligence and the intent associated with the message to the teams and on the role that the message plays in the total context of the game. In this sense it is likely that this particular function is best served by a manual procedure. The same would hold for any information regarding rules, game judgments, and decisions passed down from the Control section to the teams. However, the results of combat, unit contact, and the status-of-forces reports lend themselves quite naturally to automation wherein the Control section communicates these activities and reports to the teams via visual display and hard-copy printouts. The same data can be simultaneously stored for detailed reports, for team use, and/or for later reprocessing in the report-generating phase of the analysis. Combat and status results may be displayed in a simple format, or, if the ultimate in sophistication is desired, it is possible to have a group display with an elaborate procedure for producing a full-blown edited report. The sophistication desired depends entirely on the research objectives to be served.

The information flowing on link 2 is ideally suited for automated visual display. In particular, the development and storage of the orders generated by each team for the next interval of play in a context of automation permitting immediate card or tape production of these orders, a verification for control as required, and insertion into the computer memory banks for processing and bookkeeping requirements are all naturally suited to computer processing.

The information communicated on link 3 is best suited for visual CRT display with a light-gun capability. This may be used for addressing special characters and functions that permit the user to immediately establish data relations. In turn, the information from the Assessment section on the status of forces may be used in preparing orders that will be communicated on link 2 to Control.

The information flow of link 3 (Fig. 1) passes through the Control section and then can be assumed to be available to the teams as appropriate under a lock-in/lock-out control feature, programmed or manually addressed by the Control section, wherein a switching procedure provides the communication from the team's data banks to its display equipment. This is necessary to prevent one team from receiving information on the opposing team's forces and to provide the Control section with the proper and appropriate ability to delimit within the constraints of the war game data through lengthy printouts, checking tables, system characteristics, and the result of the last interval of play. If these functions can be performed in the context of automated communication links with display, it will provide the war gaming research to work in a context of real time, improve accuracy, and enhance the likelihood of a more accurate analysis of the final results.

Link 4 provides for the reference of information regarding data that is suited for display and for hard-copy reports to both teams. These reports may be simultaneous and they may be different as required by the rules of the game, but in any case they can be provided accurately and quickly to the teams by the computer under the auspices of the Control section.

Link 5 indicates the hard-copy requirement to store, for later report processing, the information regarding orders, units, actions, and the results of combat; intelligence reports; and special data regarding capabilities. It also provides dynamic storage of materiel consumption and the many items of detailed information necessary for sophisticated war gaming and production of a polished report. If desired, the sophistication of the computer processing capability can be made to include information on film chips for report generation or for display to the teams. Such equipment is generally rather expensive, but a capability to generate film chips for group displays should result in partial elimination of the traditional gaming tables and wall maps. Investment in this equipment must be measured against the justification of the game.

Fig. 2 shows how the display equipment available to the RED and BLUE teams and to the Control section can serve to provide the teams with assessments and bookkeeping formerly prepared as a special operation but now carried out as a computer function through the Control section. The dashed line with an arrow head on either end implies two-way communication known as a semiduplex communication link. Information may flow in both directions but in only one at any specific time. The solid line with an arrow head on only one end is known as a simplex link; it provides for information flow in only one direction in that line. The transference of the functions described abstractly in Fig. 1 into the computer-assisted war game of Fig. 2 demonstrates one possible configuration for handling information required by war-gaming objectives and performance. Assuming for the moment that the configuration shown in Fig. 2 would be in effect after the initial scenario and game objectives had been distributed to the teams and the game was under way, the terminal display hardware would provide, on a real-time basis (with lock-in/lock-out capabilities by the Control section), the immediate display of pertinent information to both teams and to the Control section on the time-shared link with the central computer. Consequently the time taken by team functions and responses required for the next interval of play can be reduced by using display equipment to provide the development of the data for the next interval

of play. At the same time that this information is being developed by each team it could be reviewed by Control and could be printed at the team terminal device responsible for hard copy. It could then be stored in the computer data files for the RED and BLUE teams as appropriate and would subsequently be

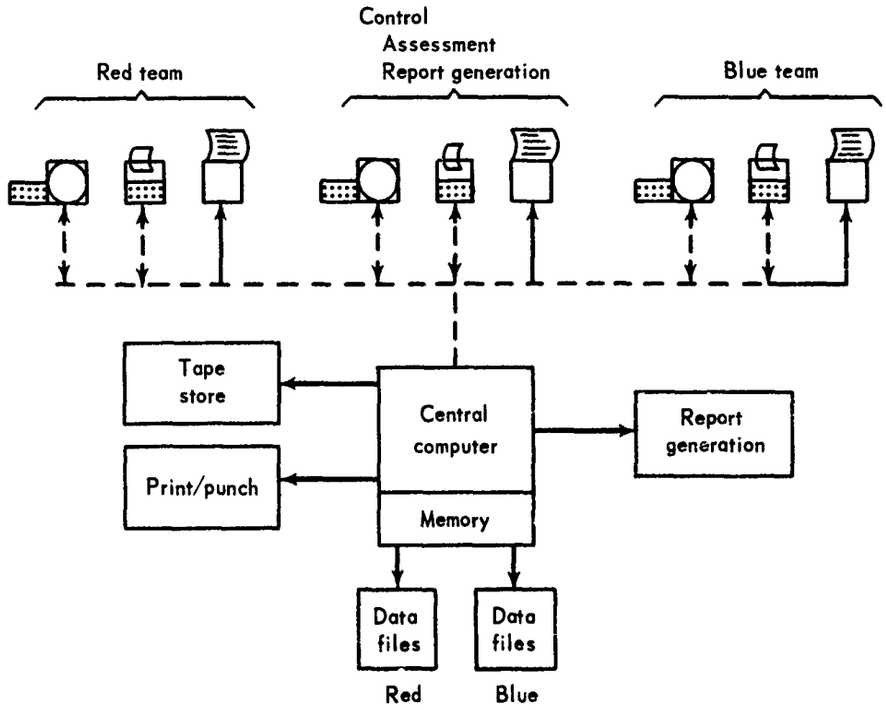
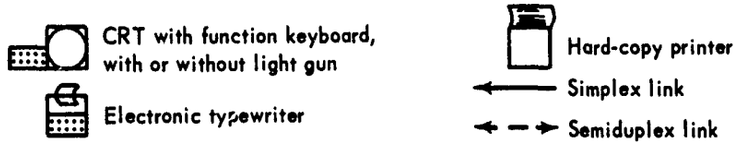


Fig. 2—Organization of Computer Display Functions



available for the development of interim reports as required. Similar activities carried on with the visual display could allow the RED and BLUE teams to quickly scan the contents of their status-of-forces files, make changes, and report these changes to the Control section at the same time they updated the information in the computer's memory banks.

IV—FUNCTIONS AND CAPABILITIES OF DISPLAY HARDWARE

The automation of a war game must contain a basic set of hardware capabilities that will permit the building of very sophisticated and advanced systems

that provide the user with a facility for data manipulation and display. The equipment described below is considered the most important and basic for providing the user with a level of communication between his display equipment and the central computer that meets the requirements discussed in the body of this paper. It is not critical to the concepts of automated war gaming that descriptions of the technical and physical characteristics of this equipment be presented; it is the intent of this section only to describe the philosophy of the capabilities in general terms in order to provide a proper context of definition for the remaining sections, which develop the concept of the automated war game. The five items of this section are not exhaustive but do make the reader aware of the general capabilities desired in a basic minimum configuration.

Activities in the Department of Defense; existence of several societies devoted to information display; and special laboratories around the country, such as MIT and the Carnegie Institute of Technology, amply demonstrate the wide interest in information-display research. These sources provide voluminous reports and monographs on the science of research on information display.

Film Chips and Projection Systems

Commercial hardware now in existence provides for the generation of 35- and 70-mm film chips and for the automatic projection of these in an appropriate mode of display. Present state of the art provides for using 35-mm film chips as data and alphabetic input to a computer and also provides for taking alphanumeric characters from a computer's memory and having the image produced on a film chip as output. More sophisticated gear provides for the activation of alphanumeric characters for reproduction on a film chip, developing the film chip, and projecting it for group display under the complete control of computer programs.

Light-Gun Manipulation

Sophisticated CRT display equipment provides the user with a light gun to address character strings displayed on the face of the display tube. In a passive mode the CRT can be used to activate critical data for decision purposes. The light gun permits the user to make changes, modifications, and additions to the data set being displayed. Physical application of the light gun to the face of the tube automatically creates the address of the character in focus; this in turn is functionally capable of triggering a wide variety of subroutines with the computer according to the control activity desired. When activated over a character the light gun automatically enters the coordinates of the character position on the face of the tube. This is translated into its address in the buffer memory, providing direct and automatic access to the display data file for any action desired by the user.

Graphics

The term graphics as currently used includes any activities dealing with vector generation, rotation, projection, and schematic display on the face of the CRT. It implies a dynamic capability by the user to modify the displayed

graphic form through control devices available on the operating console. These controls permit enlargement, rotation, erasure, and the placement of special vectors on the graphic face and may provide for automatic recording of the finished graphic through the activation of a control button. There are CRT display and special writing platforms that permit the face of the display tube to act as a receiver for input data generated through the use of a cursor light pen stroked or directed across the face of the tube. Information so placed on the face of the tube can be taken through the CRT into the computer memory by activating an input control device on the console.

Electronic Typewriter

The electronic typewriter is a device consisting of a keyboard, digital storage, and digital logic designed to display messages as they are composed, thus permitting verification, correction, or erasure. Input/output (I/O) communication is provided through the keyboard on either a duplex or semiduplex link to the computer.

With the exception of the light gun and the electronic typewriter the capabilities already described may involve expensive special hardware packages. However, they do provide the functions and capabilities most desired and required in the majority of activities in the mechanics of conducting a sophisticated war game.

Hard Copy

Hard-copy equipment is any hardware that provides the user with a permanent record of required information. Examples of such devices include high-speed printers, equipment for the generation of film chips, and material types from a computer-driven typewriter. It may also include card punching, card interpretation, and automatic tabulation. The sophistication of the copy may range from the simplest punch card to an elaborately generated report produced on a high-speed printer under computer commander control.

V—COMPUTER-LINK-AUTOMATED USER OPERATIONS

The automatic data-processing environment described in this paper permits the user to be in direct contact with all the computing capabilities and functions of the special remote-display equipment. The implications of this concept can be more clearly comprehended when the user realizes the wide variety of functions and operations that are available through such devices as the on-line electronic typewriter. The electronic typewriter is so constructed and linked to the main computer as to provide, by entering control data via its keyboard, direct access to a wide variety of I/O capabilities and software packages. The choices available to the user include automatic processing of magnetic tape to a remote printer; card punch; machine storage of information; the opportunity to indicate, through special coding to the computer, particular data and its format for display either as a table or as special graphic plot on CRT; and special "call" functions permitting the user to request mathematical or parametric calculations or statistical analysis on any particular data set.

These capabilities are only a very small part of the possibilities available to the user. The extent of the support packages to be made available through remote peripheral equipment depends entirely on the war game, the need and degree for processing data, and its relevant display to support information and game requirements.

It is possible for both teams, and the Control section under the special computer mode known as time-sharing, to carry out these activities in such a way that each user is under the impression that he has complete control of the computer, except for the special interlock that would be required by the Control section for information control on the RED and BLUE teams. The mechanism of the war game as now conducted at RAC could be completely renovated and adapted into a near-automated mode that would permit rapid and important advances. It is particularly interesting to note that in principle almost any function desired by the user can be developed through a combination of software and hardware capabilities and made available for general utilization.

A relatively new area that is being developed commercially is graphics, including the overall use of the CRT as a general display device for alphanumeric data or line plots. The exploitation of the field of graphics appears to have wide potential and certainly has many dramatic capabilities for data handling. It is intended that the user of the automatic data processing system be provided with a simplified operating technique in which the user must indicate only a very small set of control data in order to be able to use the wide variety of special support functions of the combined software and hardware in the total equipment complex available to him through his remote station.

VI—COMPUTER-ASSISTED WAR GAMING

The two principal sources of delay in any war game are the time needed to receive from the assessment and Control section the results of the last interval of play, and that used to develop the data for the next interval of play and report them to Control for approval and acceptance. The delay caused by manual processing can be significantly reduced if the war game is played in the context of a configuration of equipment that provides for visual display, hard-copy printout, and operational linkage to the computer for special computations and if these functions are available to both teams and to the Control section. The extent of the reduction would depend on the complexity of the game and the amount and format of the data transmitted between game components. The configuration of Fig. 2 can be enlarged to include computer-driven group projection displays wherein the data developed by the assessment calculations could be translated into an appropriate group display that would provide tabular information through a micro film chip or an overlay of unit positions for projection. The requirements for such configuration capabilities would depend on the context of the war game and the desirability of detail. Visual display and hard copy and communication to the central computer provided through electronic links and software programs will provide for greater certitude of game results through control of error sources, improved statistical reliance, and faster report generation. They will also

permit repeating the game or some aspect of the game more times than possible with a manually conducted war game.

In principle the advantages of a computer-assisted over the manually conducted war game are immense; they are critically important to the success of the war game as a research device to obtain planning factors and to perform comparative analysis of competing military organizations. It is possible to provide the players with computer programs to support required computational procedures for sensitivity analysis, variational analysis, and simulation subroutines for examining choices of action for the next interval of play.

Sensitivity analysis involves statistical calculations on the outcomes of a particular sequence of events observed under controlled variations. This provides for parametric trade-off comparisons and enables the user to apply more rigid mathematics to test the variation of the outcomes against the meaningfulness of the operation to which he is applying his forces. In a computer environment it is possible to provide for such analysis either through visual display or hard-copy production of the output. Such procedures are virtually impossible in manually conducted war games because of the time consumed in performing the necessary parametric study.

Where the decision process depends on the examination of several parameters, their interaction on each other, and the differential changes of each, the user is involved in a procedural technique that requires a combinatorial analysis of these parameters to determine the possible trade-off that can be made among them. For instance, there may be a prescribed relation between mobility, firepower, and ammunition type. To examine the trade-off between these three parameters would be difficult without the assistance of a program that could analyze quickly, retrieve data on the trade-offs, or perform a calculation that involved the parameters in some functional relation. To examine a trade-off of this kind manually would require searching out the weapon characteristics from special charts and plotting the variations that would be of interest. The computer can carry out this kind of activity very quickly, as desired by the user, through a special encoding procedure available through the electronic typewriter with the user's program. Such activities can be provided to the user in many ways; the specific design of the activities would depend on the configuration and type of equipment available to the user.

Capability to perform multiple plays of situations or simulations of special military problems prior to submission of orders for the next interval of play in the war game is completely denied the player in a manually conducted war game. The idea of the multiple play involves the following: The player is given a situation that requires his immediate definition of the tactics for the next interval of play. In principle it is possible to study and evaluate through the computer and the remote-display equipment the contingencies of the situation so that the best decision can be provided to the team player. To perform this would require providing input to the computer on the situation to be played; following this the computer could in principle play out several possible solutions and provide the user with a visual or hard-copy report of the results of the possibilities of the play. To provide this concept as a capability to the user requires a great deal of study of the kinds of activities it is best suited for; it is in fact providing the kind of variational analysis and sensitivity that is generally conducted as a postgame analysis. Such procedural possibilities for differential

gaming reduce the number of plays per war game needed, since the players are in principle making the best decision at that time and thus reducing the amount of statistical analysis required in postgame analysis of results.

VII—SOFTWARE FUNCTIONS

In order to establish a facility for rapid data manipulation within the structure of a complex war game it is necessary to establish unambiguous functions to the computer-based program, the capabilities expected for the remote terminals, and the organization of the use of these facilities with the computer and its requirements to process more than a single user.

Figure 3 shows the controls and links to the central computer and its various components that are necessary to provide through software the capabilities demanded by the data flux of the war game. The remote I/O display

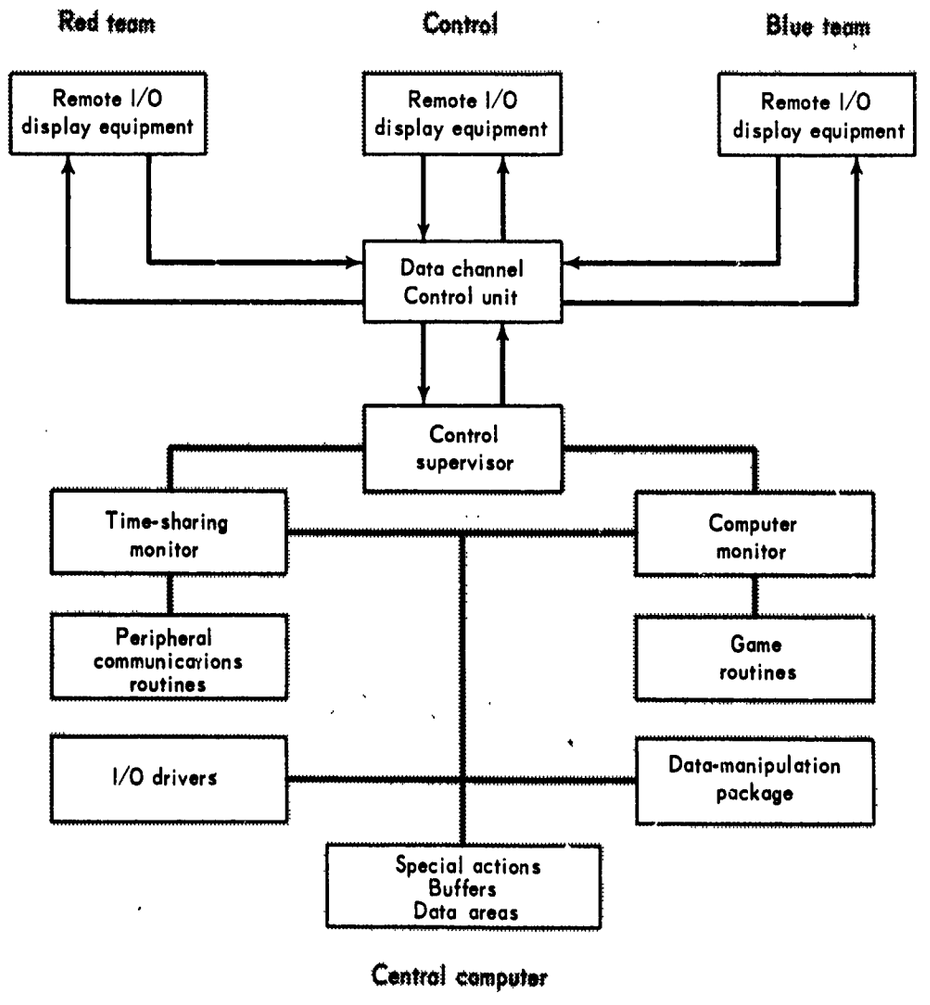


Fig. 3—Display Software Requirements

equipment shown for the RED team, BLUE team, and Control section represent the set of remote-display equipment and may be considered an elementary or complex capability. Within the central-computer software packages are eight general functional operations linked together as shown in Fig. 3. The function of the control supervisor includes the processing of the interrupt signal that establishes a link to the system for a user who wishes to communicate with the central processor. The associated control data of the interrupt signal will in turn determine what activity is desired by the user. Should there be more than one signal to the control supervisor it is necessary to establish the time-sharing mode of operation in order that the users may be served on a priority or rotational basis. If the equipment provides multiplexing or has time-sharing hardware, "simultaneous" utilization of the central computer for the number of users seeking automated processing is possible. The peripheral communication function, shown to be under the supervision of the time-sharing monitor, controls and processes all requests by the user for the utilization of his specified remote-display terminals according to the operation desired. It is to be noted that the control supervisor is a special program that is in essential control of the programming monitor supplied by the vendor of the electronic computer. This function is necessary because of the need to control the assignment of peripheral equipment to certain activities and to control and organize the computer operations when trapping or multiple trapping occurs within the control supervisor in relation to the computer monitor or within the computer monitor and its component parts. Available to the time-sharing monitor and to the computer monitor is a special package for data manipulation. It is from this package that special statistical calculations, subroutines for graphics, data plots, and any special mathematical procedures will be available to the user through a special set of control characters inserted from the function keyboard of the electronic typewriter. Each of the eight boxes shown in Fig. 3 as functional activities internal to the central computer as software packages are themselves complex and involve large amounts of the computer memory for storage. The development of these monitors and special routines include a large investment of developmental work and imagination to create the proper environment for data communication and functional activities.